FOREST PEST MANAGEMENT
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**DWARF MISTLETOE SUPPRESSION AT LLOYD MEADOW,
TULE RIVER RANGER DISTRICT, SEQUOIA NATIONAL FOREST**

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BACKGROUND:

A field site visit to the Lloyd Meadow and Castle Timber Sale Areas was completed in September, 1993. Present on the trip were Steve Pintek, Tule River District Silviculturist, and John Pronos, Forest Pest Management plant pathologist. The purpose was to evaluate the condition of the area as far as dwarf mistletoe intensity and distribution, and to assess the need for suppression.

The Lloyd Meadow area is near the headwaters of the Kern River and lies between 5500 and 6000 feet elevation. Jeffrey pine is dominant at lower elevations, with an occasional incense-cedar. Stands appear multi-aged with stems from 1 to 24 inches DBH; average site class is Dunning III. A few stands at the upper elevations contain white fir, incense-cedar, and sugar pine. Western dwarf mistletoe (Arceuthobium campylopodum) is the predominant pest and is restricted to Jeffrey pine. (The biology of western dwarf mistletoe is included at the end of this report.)

Historically, dwarf mistletoe has been a concern and priority in this portion of the Tule River District. Timber sales in 1972/73 and 1986/87 were designed to reduce the amount of dwarf mistletoe. However, the sales involved less than half of the acreage, and areas between harvest units were not treated. Most of these sites now contain heavy mistletoe infections, and many trees have Hawksworth ratings of 4 or more.

It was obvious that mistletoe is still a significant pest at Lloyd Meadow and represents a threat to overall forest health. We concluded that treatment in previously unharvested areas is justified to improve the health of those stands and prevent the gradual invasion of mistletoe into the young regeneration units. A few overstocked stands currently free of mistletoe are also threatened by adjacent infestations.

The Tule River District has submitted a Suppression Project Proposal for Forest Pest Management funding. If that project is approved, the guidelines below will help to identify specific treatments to optimize project effectiveness.

DWARF MISTLETOE GUIDELINES:

Reducing the amount of dwarf mistletoe in individual trees or stands and reducing the probability of spread from tree to tree is fairly straightforward if the basic biology of the parasite is understood. Candidate trees for treatment need to be evaluated for how much mistletoe is present in its crown and whether the mistletoe can spread to adjacent trees. The guides below provide rules for dealing with individual trees and stands; any or all of them may be appropriate for situations at Lloyd Meadow.

Direct Suppression Methods

1. Broom Pruning

Objective: To extend tree life and maintain individual treated trees on a site as long as possible.

Guidelines: Remove dwarf mistletoe witches' brooms from high-value trees only if they will have at least 30% live crown after removal of the brooms. This treatment will not eliminate mistletoe from the stand, nor will it prevent future spread. It is most often used in areas that have little or no understory, or where trees are very widely spaced.

2. Tree Removal

Objective: To remove trees expected to die within ten to fifteen years, to prevent the build-up of bark beetles, and to reduce dwarf mistletoe seed in the stand.

Guidelines: Remove trees with a DMR of 5 or 6, or a rating of 4 with mistletoe in the upper one-third of the crown. Such trees generally are not prunable, pose a threat to adjacent uninfected pines, and have a higher probability of dying within 10 to 15 years or during the next drought. It is also advisable to remove infected pines that will have less than 30 percent live crown after pruning, or are growing in dense aggregations where removal of selected individuals would benefit neighboring uninfected or slightly infected pines. Remove all trees having bole infections at a point less than six inches in diameter. Bole infections are not serious from the standpoint of spreading mistletoe, but they deform and/or lead to mortality of small trees and failure of large trees. **NOTE: Infected pines that are widely spaced where the mistletoe cannot reach adjacent susceptible trees do not have to be removed.**

3. Thinning

Objective: To reduce dwarf mistletoe and improve stand growth and tree vigor.

Rationale: Whether mistletoe is present or absent, overstocking contributes to poor tree vigor and an unnecessarily high risk of death from bark beetle attack. Uninfested stands should be thinned to improve tree health. Infested stands may be thinned using one of the two marking guides below.

METHOD A

Crop Tree DBH in Inches	Maximum Dwarf Mistletoe Rating Tolerated
1 - 2	0
3 - 4	1
5 - 6	2
7+	3

METHOD B

1. Trees less than 2" dbh: no mistletoe infections tolerated.

2. Trees more than 2" dbh: (Follow the order below for crop trees)

1-Dom and co-dom trees with NO INFECTIONS.
2-Dom and codom trees, DM in lower 1/3 crown.
3-Dom and codom trees, DM in lower 1/2 crown.
and less than 50% of the branches infected.
4-Intermediate trees with NO INFECTIONS.

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4. Branch Pruning/Eradication

Objective: To reduce or eliminate dwarf mistletoe in the stand and improve tree vigor.

Guidelines: For trees with DMR of 3 or less, or a rating of 4 and no mistletoe in the upper one-third of the crown, prune all lower branches, both healthy and diseased, at the bole up to and including the second whorl of branches above the highest visible mistletoe infection. Experience has shown that despite removing branches up through the highest infection or even one more whorl, latent infections almost certainly appear in three to five years. Whenever possible, avoid removing more than 50% of a tree's live crown. Pruning of all infected branches in infected trees in an attempt to eradicate this pest requires careful adherence to these guidelines, and will have the greatest chance of success when used on isolated high-value trees or in areas of one acre or less where infection is light. Do not attempt eradication if the pruning will result in a tree with a crown of less than 30%, or if the tree will be exposed to continued infection from adjacent infected trees. It is difficult to completely eliminate dwarf mistletoe from a stand with only one treatment. Plan to retreat the area in 3-5 years.

Indirect Suppression Methods

1. Favoring and Planting Non-Host Conifers and Hardwoods

Objective: To eventually replace infected trees with uninfected trees and to lessen future spread of dwarf mistletoe.

Rationale: Because western dwarf mistletoe (A. campylopodum) infects neither the hardwoods nor most of the conifers growing with susceptible ponderosa and Jeffrey pines, managers may favor these non-hosts so that they become a larger component of the stands. Selected individuals or small aggregations of these non-host species may be retained as buffers to movement of the parasite, or as eventual replacements for severely infected pines that cannot be removed during mistletoe treatment. Wherever there are pure stands of severely infected pines, planting of non-susceptible species may be the only way to ensure that new trees replace the pines that die or are removed.

2. Creation of Buffer Strips

Objective: To limit or stop the spread of dwarf mistletoe into a treated area from adjacent infested areas.

Guidelines: Use host-free strips to prevent mistletoe from re-entering the control area or, when the parasite is not eliminated, from leaving the site. Buffer strips should be at least as wide as the height of the highest mistletoe plants in the adjacent infested trees. Examples of existing buffers include meadows, roads, rivers, clearings, and aggregations or plantings of non-host trees.

Integrated Pest Management

Although this project targets dwarf mistletoe, other site, stand, and pest factors should be appraised. For example, if annosus root disease (Heterobasidion annosum) is known to be active in or adjacent to control areas, stump treatment with borax should be considered. Also treat green pine slash generated by pruning or tree removal to reduce the risk of pine engraver beetle (Ips sp.) buildup (see Appendix for additional information on annosus root disease and pine engraver beetles).

APPENDIX - PEST BIOLOGIES

Western Dwarf Mistletoe

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the family Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts. Western dwarf mistletoe (A. campylopodum) infects principally ponderosa, Jeffrey, and knobcone pines, and occasionally Coulter and lodgepole pines.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occasionally vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of Digger pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached, and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.

Annosus Root Disease of Pine

Heterobasidion annosum (formerly Fomes annosus) is a fungus that attacks a wide range of woody plants, causing a decay of the roots and lower bole and death of sapwood and cambium. All pines in California are susceptible; hardwoods are rarely affected.

The fungus becomes established in freshly cut stumps from air-borne spores produced by fruiting bodies (conks). It then grows into the root system

and may spread to adjacent healthy trees via root contacts. Infected pines are usually killed rather rapidly when H. annosum girdles the root collar. After a suitable period of time, conks are produced under the bark of dead trees, in decayed stumps, or in the duff at the root collar.

Local spread of H. annosum outward from a stump results in the formation of disease centers that have dead trees in the middle and dying trees on the margin. These centers usually continue to enlarge until they reach barriers such as openings or groups of non-host plants. The fungus may remain alive for as long as 50 years as a saprophyte in infected roots and stumps. Pines may seed in or be planted in centers and survive for a few years, but they eventually will be infected and die.

There are two pathogenic strains of the fungus that differ in their ability to infect various conifers in California. The "P" or pine type infects and kills all pines (although susceptibility of pine species vary), in addition to incense-cedar and western juniper. The "S" or fir type infects true fir and giant sequoia. At this time it is not certain which strain attacks Douglas-fir. Knowing which type is active in a stand will allow favoring alternate conifer species since the strains do not cross infect between the two groups listed above.

Pine Engraver Beetles

Pine engraver, Ips spp., attacks have been recorded on most species of pines in California. These beetles kill saplings, poles and sawtimber up to about 26 inches dbh and the tops of even larger trees. Attacks on live trees are usually limited to trees which are suppressed, or stressed by dwarf mistletoe, root disease, drought, fire or the attack of other insects. If fresh slash is available in the spring, pine engravers may build up in an area and cause localized mortality or top killing by mid-summer.

Attacks are made with the coming of warm weather in the spring. Attacking males bore nuptial chambers in the inner bark and release a pheromone which attracts other beetles to the attack site. If many beetles are attracted, they may attack nearby trees and cause a group kill. Within a day or two of the attack by the male, two to five females enter the nuptial chamber and after mating, each female bores an individual egg gallery which lightly scores the sapwood. The size and pattern of the combined gallery pattern is often diagnostic of the species of Ips involved. The galleries are kept open by beetles pushing boring dust out through the entrance hole. Red boring dust collecting in bark crevices or spider webs is diagnostic of a successful attack. Eggs are laid in niches along the sides of the galleries. Larvae hatch from the eggs and feed in the phloem. They eventually pupate in cells at the end of their larval mines and transform to adults.

A new generation is produced in as little as 6-8 weeks in the spring to 4-6 weeks in mid-summer (August). Thus, several overlapping generations per year may be produced. The winter may be passed in any of the life stages of larvae, pupae, or adults, depending upon which Ips species is involved.

Outbreaks in standing, healthy trees are sporadic and of short duration, and are often associated with some temporary stress or shock afflicting the host

species, such as drought or logging disturbance. Tree killing frequently occurs where green pine slash, which serves as breeding habitat is left untreated during spring and summer. To be suitable as pine engraver breeding habitat, pine slash must have bark from 1/8 to 1 inch thick (usually 3 to 26 inches diameter), must have succulent cambium and must remain moderately cool during the development period.

Fresh pine slash caused by thinning, dwarf mistletoe control work, construction or winter storm breakage can be modified in a number of ways to make it unsuitable for pine engraver breeding. One approach to minimizing damage is to schedule slash-generating activities mostly between mid-July and late-December, when the slash has a high probability of drying out, heating up, or spoiling before the beetles can complete their development. Utilization of the cut material to the smallest possible diameter will minimize the amount of breeding material available to engraver beetles. If green pine slash must be created during the sring and early summer, slash treatments are available to prevent the buildup of pine engraver populations. Because pine engravers can complete their development in about a month under ideal conditions, treatment should be carried out soon after cutting to be effective.

Slash treatment methods which generally work well include chipping, lopping and scattering slash in sunny areas to heat it up, crushing or mashing slash with logging equipment to make it unsuitable for pine engraver breeding, or piling and burning the slash within a month of cutting. Broadcast burning the slash might work if it could be done without damaging the residual stand. A method which has worked during the summer in hot climates is to pile slash in a sunny area and tightly cover the pile with clear plastic. If the temperature under the bark of slash in all parts of the pile reaches 120^{o}F, all brood currently in the pile will be killed. Lower temperatures will not be effective and, where successful, this method will not prevent reinfestation of slash piles. Because most pine engraver attacks occur within a quarter-mile from the location where the beetles emerged, high value pines can be given some protection by removing fresh pine slash to areas which do not have pines.

Two practices which should generally be avoided are piling fresh pine slash without further treatment, and allowing slash to touch or remain near valuable leave trees.